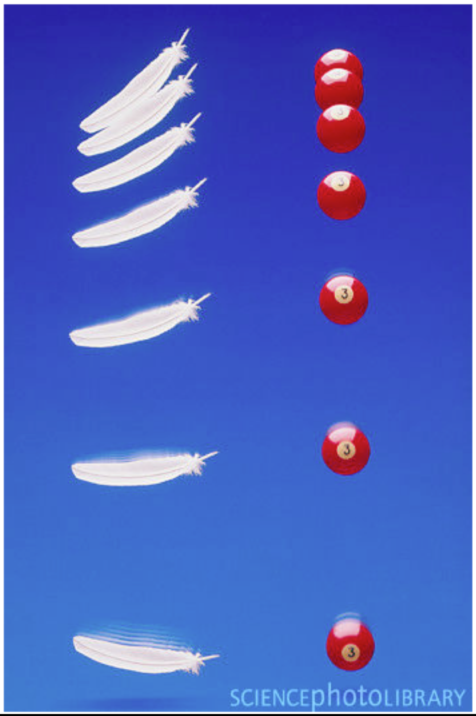


Welcome back to Physics 215

Lecture 2-1

- Last time:
  - Displacement, velocity, graphs
  - Using graphs to solve problems
- Today:
  - Using graphs to solve problems
  - Constant acceleration, free fall
- Next time:
  - More than 1 dimension!

Lectures and Homework

- Problem set 2 available on the course website under “Lectures and HW tab”
  - Generally will be posted on Friday evenings
- Lecture slide shells also available there
- Reading should be done BEFORE lectures
  - participation grades are influenced by this

Reading assignment for Thursday

- Vectors, 2D motion
- OpenStax: Sections 2.1-2.3

Exams

- Midterm 1: Tuesday, Sept 24
  Midterm 2: Thursday Oct 24
  Midterm 3: Thursday, Nov 21st
  (all midterms are during regular class times)
- Final exam: Thursday, Dec 12 3-5pm
- No makeup exams. Instead, Lowest grade will be dropped.
- Accommodations are handled through the office of disability services. Please see me at least a week before the first exam about this
- Working on a pizza and mentoring night with SPS

SG 0: You are throwing a ball up in the air. At its highest point, the ball's

A. Velocity v and acceleration a are zero

B. v is non-zero but a is zero

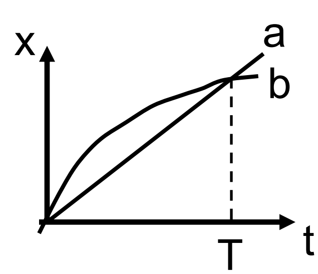
C. Acceleration is non-zero but v is zero

D. v and a are both non-zero

Fan cart demo

- Sketch graphs of position, velocity, and acceleration for cart that speeds up

SG 1

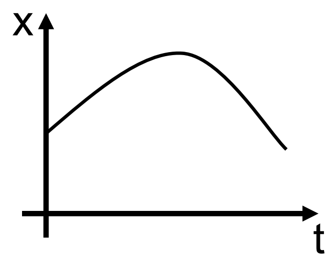


The graph shows 2 trains running on parallel tracks. Which is true:

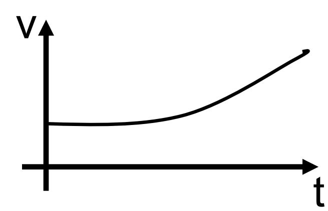
A. At time T both trains have same v
B. Both trains speed up all time
C. Both trains have same v for some t<T
D. Somewhere, both trains have same a

Interpreting x(t) and v(t) graphs

- Slope at any instant in **x(t)** graph gives instantaneous **velocity**



- Slope at any instant in **v(t)** graph gives instantaneous **acceleration**



- What else can we learn from an x(t) graph?

Acceleration from x(t)

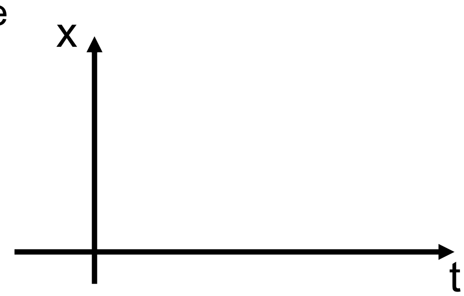
- Rate of change of slope in x(t) plot equivalent to *curvature* of x(t) plot
- Mathematically, we can write this as

  a =

  – Negative curvature
    - a < 0

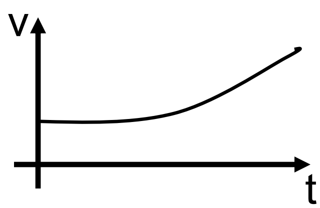
  – Positive curvature
    - a > 0

  – No curvature
    - a = 0



Displacement from velocity curve?

- Suppose we know v(t) (say as graph), can we learn anything about x(t) ?



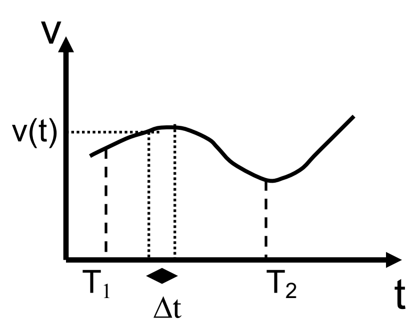
- Consider a small time interval Δt

  v =

- So, total displacement is the sum of all these small displacements Δx

  $x_f - x_i = \Sigma\ \Delta x =$

Graphical interpretation



Displacement between T_1 and T_2 is area under v(t) curve

Fan cart redux

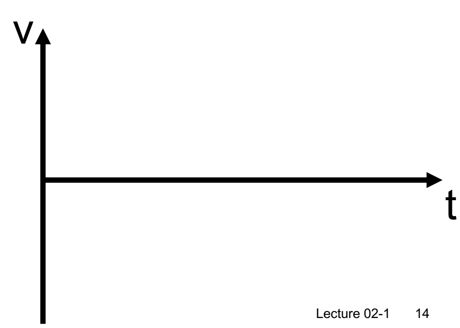
Displacement – integral of velocity

$\lim_{\Delta t \to 0} \Sigma \, \Delta t \, v(t)$ = area under v(t) curve

note: `area' can be positive or negative

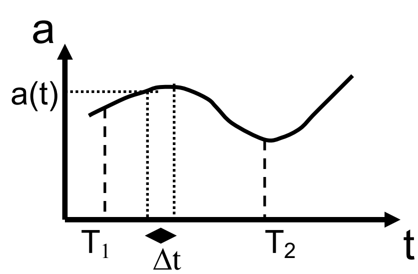
*Consider v(t) curve for cart in different situations…

*Net displacement?



Velocity from acceleration curve

- Similarly, change in *velocity* in some time interval is just area enclosed between curve a(t) and t-axis in that interval.



Summary

- **velocity** v = dx/dt
  = *slope* of x(t) curve
  – NOT x/t !!
- **displacement** Δx is
  $\int v(t)dt$
  = *area* under v(t) curve
  – NOT vt !!

- **accel.** a = dv/dt
  = *slope* of v(t) curve
  – NOT v/t !!
- **change in vel.** Δv is
  $\int a(t)dt$
  = *area* under a(t) curve
  – NOT at !!

Simplest case with non-zero acceleration

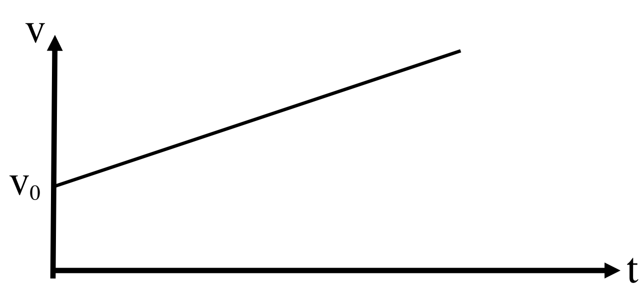
- Constant acceleration: $a = a_{av}$
- Can find simple equations for x(t), v(t) in this case

1^{st} constant acceleration equation

- From definition of a_{av}: $a_{av} = \Delta v/\Delta t$

Let

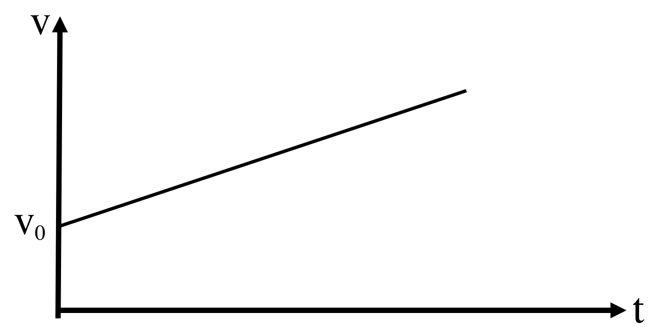
Find:



2nd const. acceleration equation

- Notice: graph makes it clear that

$$v_{av}=(1/2)(v + v_0)$$



3rd constant acceleration equation

- Using 1st constant acceleration equation

$$v = v_0 + at$$

insert into relation between x, t, and v_{av} :

$$x - x_0 = v_{av}t = (1/2)(v + v_0)t$$

yields: $x - x_0 = (1/2)(2v_0 + at)t$

or:

3^{rd} constant acceleration equation

- Alternate explanation using integrals:

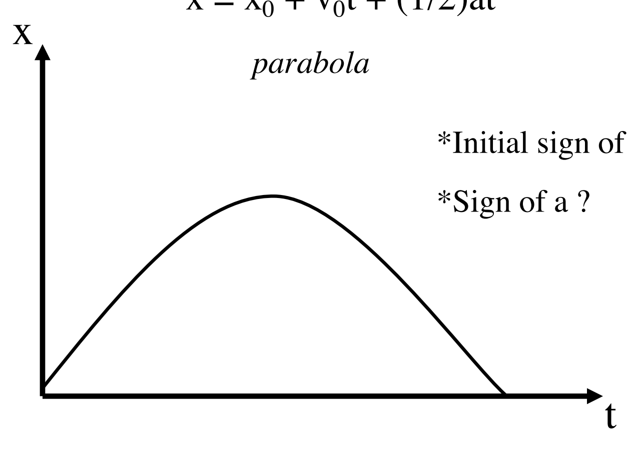
- a is a constant, $t_0 = 0$
- $v - v_0 =$ $= a(t - t_0) = a\,t$
- $v = at + v_0$
- $x - x_0 =$ $= (1/2)at^2 + v_0t$

$$\mathbf{x = x_0 + v_0t + (1/2)at^2}$$

x(t) graph- constant acceleration

$$x = x_0 + v_0t + (1/2)at^2$$

parabola



*Initial sign of v ?

*Sign of a ?

4^{th} constant acceleration equation

- Can also get an equation independent of t
- Substitute $t = (v - v_0)/a$ into

$$x - x_0 = (1/2)(v + v_0)t$$

we get:

or:

SG : An object moves with constant acceleration, starting from rest at t = 0 s. In the first 8 metronome beats, it travels 5 cm.
What will be the displacement of the object in the following eight metronome beats(mb) (*i.e.* between t = 8 mb and t = 16 mb)?

A. 10 cm
B. 15 cm
C. 20 cm
D. 25 cm

SG: An object moves with constant acceleration, starting from rest at t = 0 s. In the first 8 mb, it travels 5 cm.

What will be the displacement of the object between t = 16 mb and t = 24 mb?

A. 10 cm
B. 15 cm
C. 20 cm
D. 25 cm

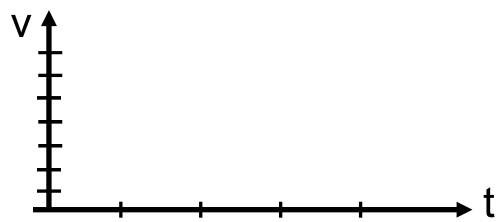
Rolling disk demo

- How far apart should the orange painted lines be?

Rolling disk demo

- Compute average velocity for each section of motion (between marks)
- Measure time taken (metronome)
- Compare v at different times

(i) 5 cm (ii) 20 cm (iii) 45 cm



Reading assignment

- Vectors, 2D motion
- OpenStax: Sections 2.1-2.3

Motion with **constant** acceleration:

1. $v = v_0 + at$
2. $v_{av} = (^1/_2)\,(v_0 + v)$
3. $x = x_0 + v_0 t + (^1/_2)\,a\,t^2$
4. $v^2 = v_0^2 + 2a\,(x - x_0)$

*where x_0, v_0 refer to time = 0 s ;

x, v to time *t*